



Airspace Systems Program

Next Generation Air Transportation System NextGen Systems Analysis, Integration and Evaluation Project

Project Plan

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Airspace Systems Program

NextGen Systems Analysis, Integration and Evaluation (SAIE) Project Plan

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1 NextGen Systems Analysis, Integration and Evaluation (SAIE) PROJECT PLAN OVERVIEW

1.1 Introduction

1.1.1 Purpose

This document describes the implementation plan for the management and execution of the Next Generation Air Transportation System (NextGen) Systems Analysis, Integration, and Evaluation (SAIE) Project within the Airspace Systems Program (ASP). A Program Plan approved by the Associate Administrator of the Aeronautics Research Mission Directorate (ARMD) covers ASP and its two Projects. The SAIE Project Plan is in response to the ASP Plan, and follows the planning guidance established by ASP and the NASA Research and Technology Development Management Requirements 7120.8. The Project plan discusses the SAIE Project within the context of NASA's role in Air Traffic Management (ATM) in support of the Joint Planning and Development Office (JPDO) and the Federal Aviation Administration (FAA). The Project plan addresses the technical approach of the Project, and the programmatic approach to its management and execution. It defines the responsibilities and activities associated with the planning, tracking, review, and reporting of the Project. The Project plan will be maintained as a configuration-controlled document that will be updated once per year.

This Plan responds to ARMD and ASP requirements and codified by the President's Budget request for FY10-15 to add more system level analysis, integration, and evaluation of research products for the Airspace Systems Program support of NextGen. Program restructuring commenced in late FY09 to accommodate these additional programmatic goals. The focus of this document is for FY10 through FY15 activities and milestones, and reflects the new direction.

1.1.2 Scope

One of the biggest challenges in expanding air traffic capacity lies in the fielding of new Air Traffic Management concepts and technologies into an integrated Air Traffic Management System such as NextGen. The primary research and development role has been undertaken by NASA's Aeronautics Research Mission Directorate (ARMD) and the primary implementation role has been undertaken by the Federal Aviation Administration (FAA).

The SAIE Project is responsible for facilitating the Research and Development (R&D) maturation of these integrated concepts through evaluation in relevant environments, providing integrated solutions, characterizing airspace system problem spaces, defining innovative approaches, and assessing the potential system impacts and design ramifications of the Program's portfolio. Opportunities to collaborate with the FAA and industry to further the development of NextGen technologies towards implementation will be sought on a continuing basis. Working with the FAA through various efforts, such as the Research Transition Teams (RTT) and other field tests are just a couple of ongoing examples of collaborative opportunities.

1.1.3 Background

The air transportation system in the U.S. continues to suffer schedule and system upsets causing congestion and delays in the NAS, even in the currently slowed economy. The systemic disruptions are attributable to many issues, some of which stem from the current air traffic management architecture and infrastructure utilized in the U.S. today, namely ground based radar control by humans of the individual aircraft. The air traffic control methods today have capacity limitations due to the workload that human controllers can safely handle and the procedures they are required to follow. Additional factors that influence systemic delays, such as weather disruption, can create a demand scenario that is very difficult to recover from in a timely manner. The predicted volumes of en route traffic near congested airspace (e.g., North East corridor), airspace very close to airports, and airport surface traffic conditions continue to stress the system and limit the capability to respond to various surges and demands. Looking at the nation's 35 busiest airports, four are already at capacity and in the absence of improvements, 27 will reach capacity limits by 2025.^[1] Environmental issues and airport capacity are two significant constraints to achieving NextGen vision for the National Airspace System (NAS) capacity in 2025^[2]. Building new airports and runways is extraordinarily expensive and can take decades to complete,^[3]. This is exacerbated if procedural constraints and separation standards between converging runways or parallel runways do not allow new runways to fit within the confines of existing airport property. Environmental issues also limit the ability of airports to expand. For example, during the 1990s, environmental issues forced 12 of the nation's busiest commercial airports to cancel or indefinitely postpone expansion projects.^[4]

Despite these constraints, air traffic is still expected to continue to increase in the coming years and could double by 2025^[5] relative to the 2004 baseline year. All other factors remaining constant, such an increase will mean longer delays at airports already experiencing delays. At airports that do not currently experience frequent delays, a dramatic increase in air traffic will likely create delays. Even if current economic conditions continue to slow the expected growth of air traffic, those same factors will demand that system efficiencies improve at an equal or accelerated rate. As the volume of traffic exceeds the capacity of the airports and the airspace to safely and efficiently accommodate the increased traffic, the risk of a reduction in safety may also arise. The associated environmental impact and economic inefficiencies alone could cost the nation \$30 billion annually.^[6]

¹ Federal Aviation Administration, Capacity Needs in the National Airspace System 2007-2025 – Future Airport Capacity Task 2, May 2007

² Frederick Wieland, Greg Carr, Alex Huang, Kris Ramamoorthy, George Hunter, Shahab Hasan, Dou Long, Bob Hemm, "Constraints Analysis", Joint Planning and Development Office, Evaluation and Analysis Division, February 2007 presentation to Airport Integrated Product Team.

³ <http://www.portseattle.org/seatac/construction/thirdrunway.shtml>

⁴ *Technology Pathways: Assessing the Integrated Plan for a Next Generation Air Transportation System*, National Academies Press, 2005, Page 17.
<http://darwin.nap.edu/books/0309097339/html/17.html>

⁵ Ibid.

⁶ *NGATS Integrated Plan*, Page 2.

1.2 Objectives

1.2.1 Project Goal and Technical Objectives

The key objectives of the NASA ASP are to:

- Improve mobility, capacity efficiency and access of the airspace system
- Improve collaboration, predictability, and flexibility for the airspace users
- Enable accurate modeling and simulation of air transportation systems
- Accommodate operations of all classes of aircraft
- Maintain system safety and environmental protection

In support of these program objectives, the major goal of the NextGen-SAIE Project is to enable the transition of key capacity and efficiency improvements to the NAS. Since many aspects of the NAS are unique to specific airport or airspace environments, demand on various parts of the NAS is not expected to increase equally as system demand grows. SAIE will provide systems level analysis of the NAS characteristics, constraints, and demands such that a suite of capacity-increasing concepts and technologies for system solutions are enabled and facilitated. The technical objectives in support of this goal are the following:

- Integration, evaluation, and transition of more mature concepts and technologies in an environment that faithfully emulates real-world complexities.
- Interoperability research and analysis of ASP technologies across ATM functions is performed to facilitate integration and take ASP concepts and technologies to higher Technology Readiness Level (TRL).
- Analyses are conducted on the program's concepts to identify the system benefits or impacts. System level analysis is conducted to increase understanding of the characteristics and constraints of airspace system and its' domains.

1.2.2 Alignment

The SAIE Project will conduct research to support two key goals for the Airspace Systems Program. Specifically, SAIE will contribute to research in the areas of maturing NextGen concepts and technologies towards higher TRL and providing system level analysis to support program portfolio management. Achieving these Program goals will provide transition paths for the program's concept and technology research directly addressing the Joint Planning and Development Office (JPDO) Operational Improvements (OI's) or Research and Development (R&D) needs, as well as addressing stakeholder needs of advancing technologies to higher readiness levels. The following quote substantiates this need:

"More resources would be helpful in areas of system level testbeds and taking technology to higher readiness levels for the advances in the Airspace Systems and Aviation Safety programs in support of NextGen."

Testimony of Dr. Raymond S. Colladay, before the Subcommittee on Space and Aeronautics of the House Committee on Science and Technology June 18, 2009

The Project is committed to increasing its interaction with the JPDO to ensure alignment with the JPDO NextGen Concept of Operations^[7] (CONOPS), to understand the rationale behind the formulation of the key JPDO documents, and to inform JPDO

deliberations with subject matter expertise and SAIE results. Additional activities such as participation on FAA/NASA RTTs are also supported. The JPDO CONOPS, Integrated Work Plan (IWP), and the R&D Plan will form the high-level project documentation with respect to concepts of operation and research questions. Particular emphasis will be placed on coordination of project research with JPDO metrics and demand forecasts. The Project is participating in JPDO activities to add detail to the current set of JPDO research needs and to validate the mapping of research needs to SAIE activities.

1.3 Technical Approach

The NextGen SAIE Project is responsible for the R&D maturation of integrated concepts through evaluation in relevant environments, providing integrated solutions, characterizing airspace system problem spaces, defining innovative approaches, and assessing potential system impacts and design ramifications of the program's portfolio.

This approach will be achieved by focusing on three areas that conduct the following activities:

- **Integration, Evaluation and Transition (IET)**
Integrates ASP concepts and technologies with each other and with existing and emerging NAS technologies to create evaluation environments that accurately represent NextGen. Evaluates more mature ASP concepts & technologies in these relevant environments. Collaborates with NextGen implementing organizations to facilitate transition of NASA-developed concepts and technologies.
- **Interoperability Research (IR)**
Performs system research and analysis key to the interoperability of ASP technologies across ATM functions to address interoperability issues critical to taking ASP concepts and technologies to higher TRL. Outcomes include analysis and design guidelines and tools, integrated solutions, and key technical capabilities common to multiple ASP concepts and technologies.
- **System and Portfolio Analysis (SPA)**
Conducts system studies on integrated ASP concepts to identify the system benefits or impacts, to provide input to the prioritization of the programmatic resources and provide guidance to researchers and developers; increase understanding of the characteristics and constraints of airspace domains and to identify and define innovative approaches for portfolio consideration.

Drawing on NASA in-house expertise, supplemented by university and industry efforts funded through the NASA Research Announcement (NRA) process, research will identify the constraints that exist in these domains, and will investigate technologies and procedures to mitigate these constraints. Further assessment will be undertaken in conjunction with industry partners in research areas that require systems analyses and evaluation.

1.3.1 Research Focus Areas

The SAIE Project has defined three research focus areas (RFAs), within which system level testing and analysis of concepts, and technologies are conducted to facilitate transition of research products to the field. These activities involve the outputs from multiple CTD RFAs, other emerging technologies from the NAS, or other existing NAS systems and infrastructure. An overview of each of the RFAs is provided below:

Integration, Evaluation and Transition (IET)

The IET RFA evaluates more mature ASP concepts & technologies in a relevant environment. The purpose of the IET phase of development is to assess the concepts and technologies in the context of real-world operations, including the other systems present in such an environment. The integration of concepts with each other and with existing and emerging NAS technologies is of particular interest in this RFA. Another way of arriving at the need for an IET activity is identification of customer's need or desire to improve a particular metric, and NASA proposes experiments involving the integration of mature concepts that together may do so.

Individual IET research activities are led by Test Engineers (TEs) functioning much like traditional Flight Test Engineers. The TEs coordinate closely with research leads from the CTD Project to integrate concepts and technologies and evaluate them in a manner that facilitates transition to the NAS. Following are some key characteristics of this collaborative approach to integration, evaluation, and transition.

- TEs serve as liaison between research leads and research partners (FAA, air carriers and airport operators.) TEs will develop operational expertise and relationships that will help identify unique constraints, sensitive issues and unforeseen opportunities.
- TEs design, procure, deploy, maintain and document field test research infrastructure
- TEs lead the effort to integrate NASA-developed concepts and technologies into the test environment as well as with existing and emerging NAS technologies
- TEs work with CTD research leads to identify evaluation requirements and develop an integration and evaluation plan that meets these requirements within the constraints of the operational environment
- TEs assist with experiment setup, execution, and data collection (e.g., NASA software recordings, observations, human factors surveys, voice recordings)
- TEs archive data and assist with analysis
- IET resources are applied to integration, evaluation, and transition tasks. CTD will ensure that sufficient software developer and analyst resources are available throughout the evaluation period.
- The TE and CTD research lead jointly develop an integration and evaluation plan that specifies roles and responsibilities for the experiment.

In addition to full-scale, high-fidelity evaluations of more mature concepts and technologies, the IET research focus area supports in-situ studies or experiments involving less mature concepts and technologies. The in-situ experiments are typically

quick-look shadow evaluations that “piggy-back” on test infrastructure developed for other purposes. The presence of subject matter experts at the test site allows them to informally evaluate the concept, and their evaluations could be placed in the context of the entire operational situation, for example, particular weather or flow conditions. The data collection infrastructure supports such in-situ experiments as well.

IET developed infrastructure and capabilities also provide data and analyses applicable to very early stages of concept and technology development.

Interoperability Research (IR)

The Interoperability Research focus area provides research analysis results that are key to the interoperability of ASP technologies and concepts that crosscut specific ATM concepts. These results complement the solutions to interoperability issues that evolve naturally from the research in other RFAs. Outcomes include analysis and design guidelines and tools, integrated solutions, and key technical capabilities common to multiple ASP concepts and technologies. The Interoperability RFA focuses on common trajectory prediction/interoperability (TP/I) and Function Allocation (FA) including human systems integration (HSI), with other focus topics to be added as required by the needs of the project and program.

The Function Allocation research thread is responsible for crosscutting human system integration activities involving multiple concepts within the ASP research portfolio, or the integration of ASP concepts into the existing Air Traffic Management (ATM) architecture. Allocation of roles and responsibilities in the NextGen environment between humans and automation, and between the flight deck and ground-based systems, is investigated within this research thread. One of the key function allocation research activities currently underway within ASP is being conducted within the Separation Assurance area of CTD. A series of ground-based simulations at Ames and flight-deck-based simulations at Langley are being conducted in FY10 and beyond. Researchers in IR will assume the lead role in ensuring that these simulations, as they are conducted, are highly integrated in terms of their assumptions, scenarios, metrics, and data collection requirements. IR researchers work closely with the SA researchers from both NASA Ames and Langley Research Centers to ensure this integration is effectively managed, conduct the cross-simulation analyses (air/ground allocation) and publish results, in collaboration with the SA researcher teams. Function allocation has been identified as key research by external reviewers, and plans include identifying opportunities to collaborate with the FAA, and to expand this research thread.

The TP/I focus provides basic trajectory prediction technology and capabilities that are key to, and commonly needed for, enabling Program research thrusts. The principle areas of TP/I research include fundamental trajectory modeling and prediction, TP requirements and validation, and trajectory synchronization to enable the interoperability across automation systems necessary for Trajectory Based Operations (TBO).

The current state-of-practice for 4D TBO is limited to specialized areas in air traffic control. Various systems use different approaches to trajectory prediction and analysis. For example, the Flight Management System (FMS) must meet the most stringent quality and reliability requirements because the system must provide precise, continuous, real-time flight guidance for lateral and vertical navigation to the pilot or

autopilot system. Some FMS use complex energy management algorithms and very detailed aircraft performance modeling, while others use simpler kinematic models of flight dynamics. Current En Route Automation Modernization (ERAM) and conflict probe automation use a higher fidelity kinematic approach while the Traffic Management Advisor (TMA) uses a hybrid of both. Each approach is valid for its specific application. However, interoperability across automation systems and seamless trajectory-based control through all flight regimes will be required for NextGen.

Trajectory synchronization, necessary to ensure the interoperability of disparate automation systems (air and ground), is key to the generation of 4D trajectory predictions in support of seamless TBO. Several considerations must be addressed: the development and use of TP algorithms that are interoperable with airborne FMS algorithms; the generation of suitable surrogates for aircraft that are not equipped with FMS capabilities; ensuring stable interaction and interoperability between multiple legacy systems that utilize their own TP capabilities; and common TP capabilities that may serve multiple automation applications. The Trajectory Prediction, Integration and Interoperability research will provide interoperable and common TP algorithms and components for NextGen necessary to support cutting-edge NextGen research concepts.

System and Portfolio Analysis (SPA)

The System and Portfolio Analysis research focus area is responsible for systems studies conducted on the program's concepts to identify the system benefits or impacts, to provide input to the prioritization of the programmatic resources, and provide guidance to researchers and developers.

To facilitate this, SPA is defining a common set of scenarios and metrics for use by the ASP. Use of common metrics will focus ASP research toward achieving system-level performance goals and objectives and enable the discipline-level RFAs to evaluate the impact of concepts at the system level. These common scenarios and metrics are also shared with JPDOs IPSA to further facilitate comparability of analysis results.

Individual concept elements need to be integrated before combined benefits can be assessed; this is achieved through integration design studies. SPA is responsible for identifying those concepts that are likely to interact and thus may be candidates for a design study. The design studies then determine how to optimally integrate the selected concept elements.

The NAS is a complex system of systems. In order to properly assess the NAS, a series of system-wide assessments will make use of the outputs from the individual design studies, airport, and metroplex studies to determine the incremental benefits achieved as ASP research progresses. This enables measurement of the progress of the ASP toward meeting the JPDO goals for NextGen.

In SPA, additional system level studies are done to increase understanding of the characteristics and constraints of various systems that make up the complex NAS, including airspace domains, and to identify and define innovative approaches for portfolio consideration.

These types of system studies may work at various TRLs to explore different domain spaces. To enable the infusion of ideas and approaches that are critical to R&D, problem spaces must be continuously explored. The SPA RFA will conduct coordinated in-house and contractual studies to characterize different problem spaces, to identify constraints, to calculate constraint sensitivities, to identify optimization opportunities, and to start the process of identifying potential solution approaches before handing off to CTD for actual development. These system studies also increase the definition of innovative concepts that either address constraints identified in the system studies or that take advantage of new understanding of the problem space to optimize efficiencies. This work primarily benefits the Program through the analysis of these innovative concepts to identify potential impacts and R&D approaches for consideration as additions to the portfolio.

1.3.2 Milestones

The milestone numbering convention adopted by SAIE is presented in Table 1. The complete list of milestones defined by the Project is provided in Table 2 through Table 5. By the end of FY15, research results will provide information for design guidance for further research and development. Over the duration of the Project, validated algorithms and prototype technologies that support the JPDO vision and capacity goals will be transitioned to the FAA and to industry for implementation. Details of the near-term technical work planned for FY10 are addressed in the Milestone Records developed by the SAIE Associate Principal Investigators (APIs).

Table 1. Milestone Numbering Convention

SAIE	.IET (Integration, Evaluation and Test) .IR (Interoperability Research) .SPA (System and Portfolio Analysis)	.4 (System level) .3 (Multi-disciplinary) .2 (Disciplinary) .1 (Foundational)	Sequence number	J (MS Joint with CTD)
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Table 2. IET Milestones and Metrics

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.4.01	Concept & Technology Readiness Assessment I	Assess opportunities to integrate NASA-developed concepts & technologies with each other and with existing and emerging NAS elements. This "connect the dots" activity will be accomplished via ongoing and deliberate interaction with CTD Project focus areas and through participation the NASA/FAA Research Transition Teams (RTTs), and requires a thorough understanding of the FAA Enterprise Architecture.	Integration, evaluation and transition plans.	Report documenting findings and recommendations.	11	2	Initial Work	SAIE.IET.4.02
SAIE.IET.4.02	Concept & Technology Readiness Assessment II	Update assessment of opportunities to integrate NASA-developed concepts and technologies with each other and with existing or emerging NAS elements. Leverage previous work, continue strong interaction with CTD Project focus areas and NASA RTTs.	Integration, evaluation and transition plans.	Updated annual report documenting findings and recommendations.	12	2	SAIE.IET.4.01	SAIE.IET.4.03

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.4.03	Concept & Technology Readiness Assessment III	Update assessment of opportunities to integrate NASA-developed concepts and technologies with each other and with existing or emerging NAS elements. Leverage previous work, continue strong interaction with CTD Project focus areas and NASA RTTs.	Integration, evaluation and transition plans.	Updated annual report documenting findings and recommendations.	13	2	SAIE.IET.4.02	SAIE.IET.4.05
SAIE.IET.4.05	Concept & Technology Readiness Assessment IV	Update assessment of opportunities to integrate NASA-developed concepts and technologies with each other and with existing or emerging NAS elements. Leverage previous work, continue strong interaction with CTD Project focus areas and NASA RTTs.	Integration, evaluation and transition plans.	Updated annual report documenting findings and recommendations.	14	2	SAIE.IET.4.03	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.3.01	Integrated Arrival/Departure/Surface Scheduling - Single Airport (PDRC and SESO elements)	The Precision Departure Release Capability (PDRC) research activity is the primary contributor to this milestone. PDRC will integrate a representative surface traffic management system (NASA SMS) with an arrival/departure management system (research version of FAA TMA/EDC) to answer the question: "Can we reduce missed departure slots by using precise, trajectory-based OFF time predictions when computing departure schedules." This milestone also draws on SESO surface optimization research. Promising SESO surface trajectory prediction and surface movement scheduling algorithms will be incorporated in PDRC. PDRC features shadow and operational evaluations by SMEs.	SME assessment of precision, accuracy and usability of PDRC schedules in an operationally relevant environment. Reduction in missed departure slots relative to current-day procedures. Operational TMA/EDC departure scheduling performance. SMS/SDSS OFF time prediction performance.	PDRC field evaluation results documented in research paper. Research Transition Product (RTP) delivered to FAA via IADS RTT.	12	1		SAIE.IET.3.05
SAIE.IET.3.02J (AS.3.6.05J)	Interval Management to Single or Dependent Parallel Runways	See CTD milestone AS.3.6.05 for Description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Interval Management with Delegated Separation and Self-Separation" for the EFICA RTT.	See CTD milestone AS.3.6.05 for Metrics.	See CTD milestone AS.3.6.05 for Exit Criteria.	12	4		

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.3.03J (AS.3.5.17J)	3D-PAM/EDA Simulations	See AS.3.5.17 for milestone description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the HITL testing and field evaluation of the Efficient Descent Advisor (EDA) tool to the FAA.	See CTD milestone AS.3.5.17 for Metrics.	See CTD milestone AS.3.5.17 for Exit Criteria.	10	4		AS.3.5.09J
SAIE.IET.3.04J (AS.3.5.09J)	3D PAM/EDA Evaluations	See AS.3.5.09 for milestone description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the HITL testing and field evaluation of the Efficient Descent Advisor (EDA) tool to the FAA.	See CTD milestone AS.3.5.09 for Metrics.	See CTD milestone AS.3.5.09 for Exit Criteria.	11	4	AS.3.5.17J	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.3.05	Integrated Arrival/Departure/Surface Scheduling - Gate-to-Gate (PDRC and SESO elements)	This extends SAIE.IET.3.01 from a single airport to a full gate-to-gate scenario. A second PDRC research system will be implemented at an FAA NextGen Testbed and linked to the NTX PDRC system. Gate-to-gate PDRC will enable more intelligent departure scheduling by accounting for surface and arrival situations at that destination airport in addition to the surface situation at the departure airport. Departure scheduling into the overhead stream will be dynamically adjusted in response to the actual situation at the destination airport rather than relying on static flow constraints.	Reduction in missed departure slots relative to current-day procedures. Operational TMA/EDC departure scheduling performance. SMS/SDSS OFF time prediction performance.	Successful integration of NASA NTX Testbed with an FAA NextGen Testbed and field evaluation of PDRC in full gate-to-gate scenario. Evaluation results documented in published paper.	14	1	SAIE.IET.3.01	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.3.06	Evaluation of Integrated Surface and Arrival/Departure Operations Tools in Representative Environment (SORM)	Evaluation of terminal traffic flow management through integrated simulation of operations incorporating runway configuration management for multiple proximate airports with multiple runways, arrival/departure balancing across the active runways, and optimized surface operations capabilities. Traffic flow management tools will be evaluated in the context of other tools and systems being used by traffic flow managers and flight crews.	Airport throughput and/or total delays with a fixed demand during steady state weather conditions and during wind shifts requiring runway configuration changes. Benefit is validated by comparing throughput to that produced by subject matter experts (SME) in the same scenarios and by comparison to the estimated theoretical maximum throughput values (considering no uncertainties or unused slots). The target for the initial algorithm is performance at least equal to an experienced SME.	Research Transition Product (RTP) delivered to FAA via IADS RTT.	13	4	AP.2.C.04 AP.3.C.05 AP.2.C.10 AP.3.C.11	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.3.07J (AS.2.6.11J)	Tactical Conflict and Resolution Functions for Congested Terminal Airspace II	See AS.2.6.11 for milestone description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Tactical Conflict and Resolution Functions for Congested Terminal Airspace" for the EFICA RTT.	See CTD milestone AS.2.6.11 for Metrics.	See CTD milestone AS.2.6.11 for Exit Criteria.	11	4	AS.2.6.09J	AS.2.6.12J
SAIE.IET.2.01J (AS.2.6.09J)	Tactical Conflict and Resolution Functions for Congested Terminal Airspace I	See CTD milestone AS.2.6.09 for Description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Tactical Conflict and Resolution Functions for Congested Terminal Airspace" for the EFICA RTT.	See CTD milestone AS.2.6.09 for Metrics.	See CTD milestone AS.2.6.09 for Exit Criteria.	10	4	AS.1.6.05	AS.2.6.10
SAIE.IET.2.03J (AS.2.6.12J)	Tactical Conflict and Resolution Functions for Congested Terminal Airspace III	See AS.2.6.12 for milestone description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Tactical Conflict and Resolution Functions for Congested Terminal Airspace" for the EFICA RTT.	See CTD milestone AS.2.6.12 for Metrics.	See CTD milestone AS.2.6.12 for Exit Criteria.	12	4	AS.2.6.11J	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.2.04 (AS.2.4.07) APG	Determine Feasibility and Benefits of One or More Candidate MSP Updates Identified in AS.2.7.11	Candidate integration opportunities between the MSP concept and NASA research are identified in AS.2.7.11. This milestone uses human-in-the-loop simulation to explore the feasibility and potential benefits of one or more of these integration opportunities (e.g.: follow-on study to the 2007 SA part-task simulations exploring system benefits related to an MSP actively managing traffic flows.)	Vetted study results (with RFAs associated with concepts analyzed) of benefits with/without MSP in terms of (e.g.): airspace throughput, workload, flight efficiency, number of conflicts, number of clearances issued.	Published study results in a relevant conference, journal, or NASA publication.	10	4		SAIE.IET.2.05
SAIE.IET.2.05 (AS.2.4.08)	MSP Requirements for the Midterm NAS	Specify operational requirements for an MSP position in the mid-term, including technical requirements (e.g.: display, decision support, information, communication/coordination) and conceptual requirements (roles and responsibilities in relationship to other humans and automation within the system.) Include discussion of how requirements might change as the NAS (and the human's/MSP's role within the NAS) evolves towards NextGen.	Vetted (with NextGen Project Leaders) mid-term MSP operational requirements (technical and conceptual), along with recommendations for how requirements might change with introduction of future NextGen capabilities and operations.	Published study results in a relevant conference, journal, or NASA publication.	11	4	SAIE.IET.2.04	

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IET.1.01J (AS.1.6.02J)	Advanced Scheduling for Congested Terminal Airspace	See CTD milestone AS.1.6.02 for Description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Advanced Scheduling for Congested Terminal Airspace" for the EFICA RTT.	See CTD milestone AS.1.6.02 for Metrics.	See CTD milestone AS.1.6.02 for Exit Criteria.	10	4		
SAIE.IET.1.02J (AS.1.4.05J)	Digital TMI Data Mining and Analysis	See CTD milestone AS.1.4.05 for Description. This is a joint milestone for which SAIE maintains a shared responsibility with CTD in support of activities contributing to the delivery of the Research Transition Product "Digital TMI Data Mining and Analysis" for the EFICA RTT.	See CTD milestone AS.1.4.05 for Metrics.	See CTD milestone AS.1.4.05 for Exit Criteria.	10	4		

Table 3. IR Milestones and Metrics

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.4.01 (AS.4.1.01)	Real-time Data Exchange for Interoperability	Conduct an experiment of real-time critical data exchange between disparate trajectory predictors. Identify timing issues and viability of exchanging data. Exchanged data may include additional trajectory constraints and aircraft behaviors to meet those constraints.	Improved trajectory Prediction accuracy relative to data shared and behavior models and increased consistency between trajectory predictions.	Demonstration of real-time data exchange between airborne and ground based systems using common language for data exchange. Deliverables include software in support of the demonstration and raw data.	12	4	SAIE.IR.3.03 SAIE.IR.3.07	Out-year milestones
SAIE.IR.3.01 (AP.3.A.07)	Develop Human/Automation Information Requirements and Implementation Recommendations for Interactions between En Route/Terminal DSTs and Humans	Identify specific operator tasks/goals/decisions addressed by ASP RFA decision aids. Identify information exchange between controller and automation. Identify how automation interacts with human operator to provide decision support, human info requirements addressed by automation, decisions supported by the automation, and implications of automation on downstream tasks.	Identified guidelines will address en route/terminal domain. Two ASP tools will be evaluated, with recommendations for implementation of those tools in NextGen. Recommendations will be validated with operational SMEs familiar with the evaluated DSTs (through participation in HITL simulation studies)	Report to identify specific operational tasks/goals/decisions addressed by ASP automation, information requirements for human operators and automation technologies, and issues impacting downstream tasks/operations. Includes matrix of how ASP automation addresses tasks/goals/decisions and information needs of controllers for two ASP/CTD tools.	12	2	SAIE.2.01	Out-year milestones

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.3.02	Managing Trajectory Uncertainty to Meet Performance Requirements	Methods for managing/reducing trajectory uncertainty to meet specified performance requirements shall be developed. The prioritization of errors to be addressed based on critical performance requirements shall be examined.	Trajectory prediction accuracy	Conference/white paper detailing example of reduction of uncertainty error to meet a performance requirement	13	4	SAIE.IR.2.03 SAIE.IR.2.04	Out-year milestones
SAIE.IR.3.03 (AS.3.1.02)	Identification of Data for Interoperability	Identify critical aircraft behavior data for exchange for interoperability. Cross compare capabilities documents. Identify similarities in behavior models. Determine most significant data for exchange to uniquely identify aircraft behavior to meet those constraints.	Increased trajectory consistency relative to data shared and behavior models, number of new functions to support interoperability. # of TPs analyzed.	Systems analysis of critical data to be exchanged between disparate systems (conference/journal paper).	10	1	AS.3.1.01	SAIE.IR.3.07 SAIE.IR.4.01
SAIE.IR.3.04 (AS.3.1.03) (Critical)	Comprehensive Assessment of Intent Errors.	Collection and analysis of a statistically significant set of airborne and ground-based intent information to determine the makeup, frequency, and source of TP intent errors that NextGen must resolve to achieve targeted levels of system performance.	Trajectory prediction errors, as a function of measured (or inferred) intent errors for relevant conditions that are key to NextGen automation applications.	Conference/journal publication documenting categorizations of relevant intent errors in terms of the relative impact (on TP accuracy), source and frequency of occurrence.	11	4		SAIE.IR.3.08

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.3.05 (AS.3.1.04) (Critical)	Reusable Trajectory Algorithms for Multiple Airspace Regions	Validation of common trajectory modeling methods for representing NGATS-relevant (e.g., FAA) approach/departure procedures through terminal airspace accounting for specific runway, altitude and speed scheduling. Determine level of consistency between trajectory modeling methods between en-route, terminal and surface tools to enable interoperability.	Trajectory prediction accuracy, reliability	Terminal Area Sensitivity Studies (Paper)	11	4	AS.2.1.03 AS.2.1.05 AS.2.1.06 SAIE.IR.2.02	SAIE.IR.3.09
SAIE.IR.3.06 (AS.3.1.05)	Application of Trajectory Prediction Validation Techniques	Develop example of the traceability between requirements and validation metrics. Apply methodology developed in AS.2.1.02 to example trajectory predictors. Identify and collect appropriate validation data.	Fidelity of scenario, # of TPs analyzed.	Software deliverable of the GenAlt Logic for Terminal. FROM DATABASE: Conference/journal publication documenting quantitative analysis and metrics using available data.	10	4	SAIE.IR.2.02	SAIE.IR.3.09

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.3.07 (AS.3.1.06)	Implement Data Exchange Language	Implement a common language for data exchange in multiple trajectory predictors. Compare complex trajectories sharing critical data. Examine effects of exchanged data on trajectory accuracy.	Trajectory Prediction accuracy relative to data shared and behavior models	Paper on validation of algorithms for terminal/super density operations. FROM DATABASE: Experiment with disparate trajectory predictors exercising common data exchange language to analyze accuracy improvements. Deliverables include software in support of the demonstration and raw data.	10	4	SAIE.IR.3.03	SAIE.IR.3.08 SAIE.IR.3.09 SAIE.IR.4.01
SAIE.IR.3.08 (AS.3.1.07)	Common Trajectory Modeling	Develop a standard library of functions based on behavioral/mathematical models which can be interchanged between disparate trajectory predictors	Trajectory prediction accuracy in 4 dimensions	Library of trajectory prediction functions capable of being used by multiple systems	12	4	SAIE.IR.3.04 SAIE.IR.3.07	Out-year milestones
SAIE.IR.3.09 (AS.3.1.08)	Advance TP Performance Modeling	Improve trajectory prediction performance through enhancement or exchange of aircraft performance data. Examine different performance model libraries for integration with NextGen tools.	Trajectory accuracy, predictability	Check-in of new aircraft performance models	13	4	SAIE.IR.3.05 SAIE.IR.3.06 SAIE.IR.3.07	Out-year milestones

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.3.10	Develop Initial Human/Machine and Air/Ground Functional Allocation Strategies	The functional allocation strategies will be based on literature review, simulations and lessons learned from NASA and other agencies research activities related to NextGen. Furthermore, as needed, the researchers will work with CTD project to plan coordinated air/ground	Controller and pilot workload measures for function allocation strategies. Findings and recommendations for future simulations, potential for NextGen implementation.	Initial report documenting findings and recommendations for function allocation strategies for combined domains (flight-deck and ground-based).	11	4		SAIE.IR.3.11
SAIE.IR.3.11	Multi-Domain Function Allocation Concepts for Flight-Deck and Ground-Based Systems	Leveraging the results of previous HITL simulations for function allocation, work with CTD researchers to develop new or modified FA strategies for subsequent HITL simulations, including experiment planning, conduct of the simulation(s), and data analysis.	Controller and pilot workload measures for function allocation strategies. Findings and recommendations for HITL simulations, requirements for NextGen implementation.	Final published report documenting findings and recommendations for function allocation strategies for the combined domains (flight-deck and ground-based).	13	2	SAIE.IR.3.10	Out-years milestones

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.2.01 (AP.2.A.10)	Human/Automation Information Requirements and Implementation Recommendations for Interactions between Near-airport and Surface Taxi DSTs and Humans	Identify specific operator tasks/goals/decisions addressed by ASP/SESO decision aids. Identify information exchange between controller and automation. Identify how automation interacts with human operator to provide decision support, human info requirements addressed by automation, decisions supported by the automation, and implications of automation on downstream tasks.	Identified guidelines will address SESO surface domain. Two ASP tools will be evaluated, with recommendations for implementation of those tools in NextGen. Recommendations will be validated with operational SMEs familiar with the evaluated DSTs (through participation in HITL simulation studies)	Report to identify specific operational tasks/goals/decisions addressed by ASP automation, information requirements for human operators and automation technologies, and issues impacting downstream tasks/operations. Includes matrix of how ASP automation addresses tasks/goals/decisions and information needs of controllers for two ASP/SESO tools.	10	4	AP.1.A.01 AP.2.A.01 AP.3.A.01	SAIE.IR.3.01 AS.3.6.04
SAIE.IR.2.02 (AS.2.1.02)	Formal Methods for Validation	Derive a formal methodology for validating trajectory prediction algorithms. Identify appropriate types of data sets for validating the TP process. Identify a common format for collection of data into a searchable database.	Trajectory accuracy metrics.	Paper on validation methodology.	10	1		SAIE.IR.3.06

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.IR.2.03 (AS.2.1.09)	Trajectory Uncertainty Modeling	Application of trajectory uncertainty modeling methods in disparate trajectory systems. Analysis of growth of uncertainty as a function of look-ahead time on different phases of flight.	Trajectory prediction accuracy, quantification of uncertainty in trajectory predictions.	Conference/Journal or White paper on TPUBS, application of trajectory uncertainty toolbox on CTAS.	10	4	AS.2.1.04	SAIE.3.02
SAIE.IR.2.04 (AS.2.1.10)	Determination of Performance Requirements for NextGen Trajectory Predictors	"Develop methods to determine, for a target concept/system, the TP accuracy needed to be to achieve the minimum acceptable system/concept performance as well as identify sources of errors. These methods determine the level of TP performance requirements as a function of the minimum acceptable level of concept/system performance. They study the sensitivity of the TP to the models, functions and assumptions made by the driving concept."	Sensitivity of key concept performance indicators as a function of the performance of the underlying trajectory prediction, sensitivity of the performance of a TP as a function of the models, algorithms, and assumptions.	Demonstration of simulation platform for NEXTGEN concept/DST.	11	4	AS.1.1.01 AS.1.1.02	SAIE.IR.3.02

Table 4. SPA Milestones and Metrics

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.4.01	Portfolio Analysis I	Conduct the overarching portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with data. NAS internal annual report. Presentation at ASP TIM.	11	2	SAIE.SPA.2.04 SAIE.SPA.3.01	SAIE.SPA.2.06 SAIE.SPA.4.02
SAIE.SPA.4.02 (AP.4.A.02J)	Portfolio Analysis II	Annual update of the portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis, and will include the latest research results and information available for the ASP concepts and technologies being developed.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with data. NAS internal annual report. Presentation at ASP TIM.	12	2	SAIE.SPA.2.04 SAIE.SPA.2.05 SAIE.SPA.2.06 SAIE.SPA.4.01	SAIE.SPA.2.08 SAIE.SPA.4.04

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.4.03 (AS.4.7.02)	System-Level Benefits Assessment of Combined Concepts II	Performance assessment of integrated NextGen concepts and technologies. Emphasis on capacity performance, robustness to Wx and non-normal events, and top-level safety performance indicators (baseline and three NextGen options). This assessment will include explicit modeling of at least one metroplex with major concepts and technologies of DAC, TFM, Terminal Area, SA and Surface.	System-level capacity, robustness, and system level performance indicators.	Published paper on assessment results, integrated concept option descriptions	14	3	SAIE.SPA.2.06 SAIE.SPA.2.08 SAIE.SPA.3.03 SAIE.SPA.3.04	Out-year milestones
SAIE.SPA.4.04 (AP.4.A.02)	Portfolio Analysis III	Annual update of the portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis, and will include the latest research results and information available for the ASP concepts and technologies being developed.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with updated data. NAS internal annual report. Presentation at ASP TIM.	13	2	SAIE.SPA.2.06 SAIE.SPA.2.08 SAIE.SPA.3.04 SAIE.SPA.4.02	SAIE.SPA.4.05

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.4.05 (AP.4.A.02)	Portfolio Analysis IV	Annual update of the portfolio analysis for the Airspace Systems Program to provide decision support information regarding the relevance of the portfolio. This will be a collaborative effort with the JPDO IPSA and FAA ATO-P and will make use of the on-going JPDO and FAA portfolio analysis, and will include the latest research results and information available for the ASP concepts and technologies being developed.	Coverage of concepts by decision support framework. Concepts analyzed. Design studies identified and prioritized.	Decision support analytical framework populated with updated data. NAS internal annual report. Presentation at ASP TIM.	14	2	SAIE.SPA.2.08 SAIE.SPA.3.07 SAIE.SPA.3.08 SAIE.SPA.4.04	Out year milestones
SAIE.SPA.3.01 (AS.3.7.07)	Common Scenarios I	Develop common scenarios, metrics and assumptions for system-wide, and regional assessments and design studies. They will be shared with RFA researchers and used in their experiments as appropriate, to provide consistency and comparability with other concepts seeking similar system performance benefits.	The set of scenarios includes a baseline set for the selected weather days (chosen from 2006 by previous cluster analysis), future scenarios in 0.5X increments of demand up to at least 2X including demand in years 2018 and 2025. Concept specific scenarios and alt future scenarios will be included as needed by CTD and for use in system-wide benefit assessment	Set of common scenarios published on NX for access by NASA researchers.	11	1	AS.3.7.06	SAIE.SPA.3.04 SAIE.SPA.3.03 SAIE.SPA.4.01 SAIE.SPA.2.06

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.3.02 (AP.3.A.04)	Formulation and Initial Analysis of Metroplex Operational Concepts and Approaches	Definition, analysis and refinement of metroplex operational concepts at TRL 0 and TRL 1. The concepts explored address the metroplex constraints identified in previous work under AP.2.A.07, or use the metroplex-unique characteristics identified in previous work to optimize efficiencies.	Initial descriptions of metroplex concepts to include the analytical results of potential benefits of the concepts and the R&D requirements for advancing the concept.	Published report documenting the analysis methods, assumptions and results including descriptions of metroplex concepts.	11	2	SAIE.SPA.2.02	SAIE.SPA.3.06
SAIE.SPA.3.03 (AS.3.7.10)	System-Level Benefits Assessment of Combined Concepts I	Performance assessment of integrated NextGen concepts and technologies. Emphasis on capacity performance, robustness to weather (baseline and three NextGen options.) This assessment will include explicit modeling of at least one terminal area integrated with TFM, DAC, and explicit modeling of at least two SA concepts.	System-level capacity and robustness	Published paper on assessment results, integrated concept option descriptions	12	2	SAIE.SPA.1.01 SAIE.SPA.2.04 SAIE.SPA.2.05 SAIE.SPA.3.01	SAIE.SPA.4.03 SAIE.SPA.2.08

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.3.04 (AS.3.7.08)	Common Definitions Phase III	Refined/Updated common sets of metrics, assumptions and demand sets.	Completeness of common definitions set, with verified applicability/traceability to JPDO Goals/Objectives, and Metrics. Broad and appropriate use by NexGen Airspace Program RFAs in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper that documents the common metrics, demand sets and assumptions.	12	1	SAIE.SPA.1.01 SAIE.SPA.3.01	SAIE.SPA.2.08 SAIE.SPA.3.07 SAIE.SPA.4.03 SAIE.SPA.4.04
SAIE.SPA.3.05 (AP.3.A.05)	Workload-sensitive rapid emulation of human operators for fast-time simulations	Refine the rapid emulation method so that distributions in the table are dynamically affected by the changing workloads experienced by operators.	Human response delay and probability as a function of changing workload demands	Report to include dynamic table of response delay distributions and human decision probabilities.	12	1	SAIE.SPA.2.01 SAIE.SPA.2.03	Out-year Milestones

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.3.06 (AP.3.A.12J)	Definition and Analysis of Integrated Metroplex Operational Concepts and Approaches	Definition, analysis and refinement of integrated metroplex operational concepts at TRL 1. The concepts integrated and explored address the metroplex constraints identified in previous work or use the metroplex-unique characteristics identified in previous work to optimize efficiencies.	Descriptions of integrated metroplex concepts to include the analytical results of potential benefits of the concepts and the R&D requirements for advancing the concept.	Published report documenting the analysis methods, assumptions and results including descriptions of the integrated metroplex concepts.	13	1	SAIE.SPA.2.02 SAIE.SPA.3.02	Out year milestones
SAIE.SPA.3.07	Common Scenarios III	Refined/Updated common sets of metrics, assumptions and demand sets.	Completeness of common definitions set, with verified applicability/traceability to JPDO Goals/Objectives, and Metrics. Broad and appropriate use by NexGen Airspace Program RFAs in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper that documents the common metrics, demand sets and assumptions.	13	1	SAIE.SPA.3.04	SAIE.SPA.3.08 SAIE.SPA.4.03 SAIE.SPA.4.05

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.3.08	Common Scenarios IV	Refined/Updated common sets of metrics, assumptions and demand sets.	Completeness of common definitions set, with verified applicability/traceability to JPDO Goals/Objectives, and Metrics. Broad and appropriate use by NexGen Airspace Program RFAs in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper that documents the common metrics, demand sets and assumptions.	14	1	SAIE.SPA.3.07	SAIE.SPA.4.03 SAIE.SPA.4.05
SAIE.SPA.2.01 (AP.2.A.04)	Rapid Emulation of Human Operators for Fast-Time Simulations	Improve the fidelity of fast/real time simulations by representing operators with choice probability and response delay distributions developed through HITL and cognitive modeling of the part task data. Allows segregation of human operator issues from automation development issues in ASP simulations.	Delay distributions and human decision probabilities for operator interventions in planned simulations.	Report to include a static table populated with delay distributions and human decision probabilities.	11	1	SAIE.IR.2.01 AP.3.A.01	SAIE.SPA.3.05

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.2.02 (AP.2.A.07)	Determine Research Issues that are a Critical Path to Metroplex Capabilities	Determination of the capabilities and key research issues to addressing metroplex issues. Where appropriate, determine what data requirements and methods exist from airport and terminal operations for enabling safe and efficient regional airport usage (e.g. runway configuration or parallel runway operations).	Key research areas address at least the research issues identified by the JPDO R&D Plan, issues associated with weather disruptions, airport configuration changes, and traffic density implications of increasing the utilization of regional airports, and results of Airspace Program metroplex research tasks. Results demonstrate consideration of advanced NextGen operational capabilities. Concepts explored will feed the development and validation of unique concepts dealing with the dense metroplex operations.	NASA internal report summarizing the total efforts/ accomplishments of the NRAs and a bibliography listing all of the publications that came out of the efforts.	10	4	Initial Work	SAIE.SPA.3.02

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.2.03 (AS.2.7.01)	Develop Method for Modeling Human Workload in Fast-time Simulations, Validate Models against Workload Measurements.	Human workload is a critical limitation on current NAS operations. Under NextGen, automation will play a greater role, but humans will still play important roles in NAS operations. To effectively study the benefits/limitations of new NextGen concepts, human workload needs to be represented in the fast-time simulations used to model the NAS. Initially, workload for humans in current day operations must be modeled and those models validated against available real world data. This provides baseline workload models for comparison with models representing future transitional states as the NAS migrates toward the NGATS concept of operations. As the role of humans in NextGen concepts becomes better defined, workload models for those roles will be updated.	Method reduces the uncertainty bounds by 50% for typical Air Midas analyses.	Publication of research results in relevant conference or journal.	10	4	Initial Work	SAIE.SPA.3.05 (AP.3.A.05)
SAIE.SPA.2.04 (AS.2.7.03)	DAC-TFM Design Study I	Investigate interactions across DAC and TFM operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). Collaboratively identify relevant DAC and TFM concepts and research questions related to their interoperability (e.g.: Understand how a DAC resectorization concept interoperates with a TFM concept.)	Vetted (SPA, DAC, & TFM) design study results (capacity, delay and efficiency at a minimum) from simulation of DAC-TFM interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents DAC TFM interactions.	11	2	Initial Work	SAIE.SPA.3.03 SAIE.SPA.4.01 SAIE.SPA.4.02

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.2.05	System Constraints, Demand/ Capacity Analysis	Analysis of the NAS from a demand/ capacity perspective to broaden characterization of the domain and increase understanding of the physical and operational constraints (including sensitivities)	Identification of constraints and over-demanded resources.	Published report documenting the analysis methods, assumptions and results	11	2	SAIE.SPA.1.01	SAIE.SPA.2.07 SAIE.SPA.3.03 SAIE.SPA.4.02
SAIE.SPA.2.06	Design Study II	Investigate interactions across at least two CTD operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). RFA concepts (e.g., SA, SDO) for integration studies are determined through the portfolio	Vetted (SPA, relevant CTD RFAs) design study results (capacity, delay and efficiency at a minimum) from simulation of integrated CTD concepts interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents integrated concept interactions.	12	2	SAIE.SPA.3.01 SAIE.SPA.4.01	SAIE.SPA.4.02 SAIE.SPA.4.03 SAIE.SPA.4.04
SAIE.SPA.2.07	System Constraints, Demand/ Capacity Analysis II	Analysis of the NAS from a demand/ capacity perspective to broaden characterization of the domain and increase understanding of the physical and operational constraints (including sensitivities)	Identification of constraints and over-demanded resources.	Published report documenting the analysis methods, assumptions and results	13	2	SAIE.SPA.2.05	Out-year Milestones

Milestone ID	Title	Description	Metrics	Exit Criteria	Sched Comp		Deps	Feeds
					FY	Q		
SAIE.SPA.2.08	Design Study III	Investigate interactions across at least two CTD operational concepts via performance trade-studies in a common simulation environment (i.e. ACES or similar platform). RFA concepts (e.g., SA, SDO, TFM) for integration studies are determined through the portfolio	Vetted (SPA, relevant CTD RFAs) design study results (capacity, delay and efficiency at a minimum) from simulation of integrated CTD concepts interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents integrated concept interactions.	13	2	SAIE.SPA.3.04 SAIE.SPA.3.04 SAIE.SPA.4.02	SAIE.SPA.4.03 SAIE.SPA.4.04 SAIE.SPA.4.05
SAIE.SPA.1.01 (AS.1.7.02)	Research Game Theoretic Concerns Related to NextGen System Operation	Gaming of the future NextGen ATC/ATM system, by the various user groups of the NAS will be explored. Changes due to NextGen deployment should provide fair and equitable access among the various NAS user groups. This research will explore the various ways the future NextGen ATC/ATM system alternatives could be gamed for individual advantage, to the detriment of overall system performance. This may reveal where constraints on gaming behavior could be required.	Project Review of Gaming Scenarios considered, and concurrence that primary gaming issues have been considered/addressed.	Publication of research results in relevant conference or journal.	10	4	Initial Work	SAIE.SPA.3.04 SAIE.SPA.3.03 SAIE.SPA.2.05

1.3.3 Externally Tracked Milestones

The SAIE Project is tracking the following milestones as Key Milestones, Integrated Budget and Performance Document (IBPD) Milestones, supporting an Agency Performance Goal (APG), or as High Performance Project Goals. The ASP Plan describes an APG to “Determine the feasibility and benefits of one or more candidate Multi-Sector Planner concepts (APG 10AT06).” Key milestones are tracked externally to the Project but are not IBPD, APG, or High Performance Program Goal (HPPG) milestones. See Appendix B for a formal definition of the HPPG. Milestone numbers are with reference to version 1.0 of the Project Plan.

Specific Milestones:

SPA:

SAIE.SPA.2.04 (DAC-TFM study) (Key)

SAIE.SPA.3.03 (system assessment) (Key)

IR:

SAIE.IR.2.02 (validation methods) (Key)

SAIE.IR.3.03 (data for interoperability) (Key)

IET:

SAIE.IET.2.04 (formerly AS.2.4.07) (MSP) (FY10 APG MS)

The EDA work (SAIE.IET.3.03J and SAIE.IET.3.04J) in general supports the project’s HPPG.

2 PROJECT IMPLEMENTATION

2.1 Resources

Text removed from External Release version of Project Plan

Table 5. NextGen SAIE FY10-15 Resources

Table removed from External Release version of Project Plan

2.1.1 FTE & WYE

Text removed from External Release version of Project Plan

2.1.2 Procurement

Text removed from External Release version of Project Plan

2.1.3 Facilities and Laboratories

The SAIE Project will utilize NASA simulation facilities and laboratories in FY10 in support of research objectives. Requirements for use beyond FY10 will be determined during the preceding year of Project execution and adjusted as needed to reflect new knowledge and changes in available resources.

Airspace Operations Laboratory (AOL): The AOL evaluates ATM concepts and explores human-system interaction issues in a high-fidelity human-in-the-loop simulation environment designed to allow rapid prototyping of NextGen concepts. This environment allows simulations of aircraft, ATM systems and communication infrastructure for both current day operations and a variety of future, highly automated concepts. Controller workstations are realistic emulations of today's en route, Terminal Radar Approach Control (TRACON) and oceanic systems. They also include a full suite of advanced decision support tools and automated functions for conflict detection and resolution, trajectory planning, scheduling and sequencing, and managing advanced levels of airborne equipment. The AOL supports Multi-Sector Planner (MSP) milestones SAIE.IET.2.04 (AS.2.4.07) and SAIE.IET.2.05 (AS.2.4.08). Functional allocation milestone SAIE.IR.3.10 is also supported by the AOL.

NASA/FAA North Texas Research Station (NTX): The NTX is a collaborative effort between NASA Ames Research Center and several Federal Aviation Administration (FAA) organizations and supports NextGen research through field evaluations, shadow testing, simulation evaluations and data collection and analysis. Since 1995, NTX has been the site for numerous air traffic management automation tool field evaluations including: Traffic Management Advisor (TMA), Final Approach Spacing Tool (FAST), Conflict Prediction and Trial Planning (CPTP), Collaborative Arrival Planning (CAP) and Direct-To (D2). In addition to conducting these large-scale field evaluations, the NTX team (NASA civil servants and contractors) has developed expertise in: airspace and surface operations analyses; ATC, air carrier and airport procedures; integrating research prototype systems into operational

environments and the collection and analysis of quantitative and qualitative air transportation system data sets. The NTX supports IADS RTT milestones SAIE.IET.3.01, and SAIE.IET.3.05 and SAIE.IET.3.06 in out years.

Airspace Concepts Evaluation System (ACES): The ACES simulation environment is a NASA computer simulation of the air transportation system; this is a multi-fidelity, non-real-time modeling and simulation system with full gate-to-gate representation of all the major components of the NAS. NASA and others have used ACES to perform various air traffic management studies by simulating today's traffic volume (1X) and conditions as well as future traffic volumes (2X and 3X) and conditions. The ACES supports milestones SAIE.SPA.4.01.

2.2 Management

2.2.1 Organizational Structure

The SAIE Project management team consists of a Principal Investigator (PI), Project Manager (PM), and Project Scientist (PS). The management team is supported by a group of research and programmatic professionals. Each of the three RFAs are guided by an Associate Principal Investigator (API), who is responsible and accountable to the PI for supporting the technical content and the Milestone Record contract execution of their respective RFAs. Figure 1 illustrates the SAIE management structure. The PI and PS, with input from the APIs, define the approach towards reaching Program goals, objectives, and requirements for the Project. The APIs assist the PI and PS with the planning and execution of the Project's objectives. A detailed description of these roles, and other supporting roles within SAIE, is provided in Appendix A.

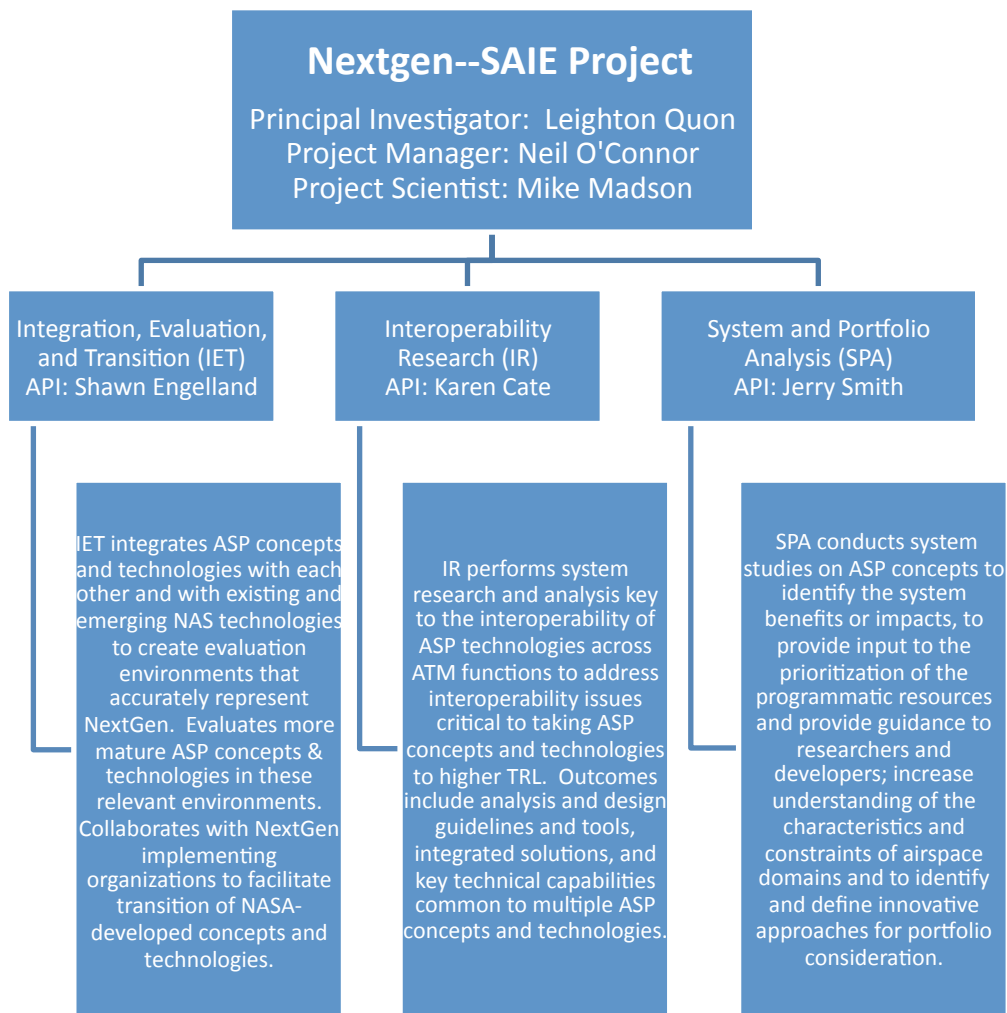


Figure 1. Project Management Structure

2.2.2 Project Reporting and Reviews

Reporting and reviews with the SAIE Project and ASP include scheduled telecons, and internal and external technical peer reviews. Specific examples of the Project reporting and reviewing requirements are presented below:

Reporting:

- Weekly telecons that include the PI, PM, PS, APIs, Associate Project Manager (APMs), and other Project support staff as required. Project-related near-term and strategic planning, issues, and actions are discussed during these telecons.
- Weekly ASP telecon that includes participation of the PI, PM, and PS from the CTD and SAIE Projects. Program-level strategic issues and near-term actions are discussed during these telecons.

- Bi-monthly ASP Business Telecons that include participation of the ASP PIM, and the Project PM, APM and Program Analyst. Program-level business issues and reporting are covered during these telecons.
- Bi-weekly SAIE Business Team Telecons that include participation of the SAIE PI, PM, APMs, and Center Resource Analysts. Project and Program-level business issues and reporting are covered during these telecons.
- Weekly Project status reports are provided to Center management.
- The PI, PM, and PS from the SAIE and CTD Projects will meet periodically to discuss common issues and inter-Project coordination and collaboration. Technical planning and coordination between Project APIs will be conducted as required.

Reviews:

- ARMD mid-year and year-end reviews of the SAIE Project are presented by the PI to the ARMD Associate Administrator (AA) directly. These reviews are provided to the ASP PD for comment prior to presentation to the ARMD AA.
- Technical peer reviews (internal and/or external) will be held annually. The schedule for, and the content of, these reviews will be determined by ASP and ARMD.

2.3 Controls and Change Process

The processes for documenting milestone completion and for change control in ASP and its Projects are hierarchical. The ASP Program Plan is the agreement and top-level document that describes the program, and is the controlling document for program content and management. The Program Plan is submitted by the PD and the Center Directors (CD) / Center Points of Contact (POCs), for approval by the ARMD AA. The SAIE Project Plan is the agreement between the PI, PM, CD/POCs, and the PD for ASP. The Project plan documents the technical plan, milestones, deliverables, schedules, resource management approach, etc., to ensure successful delivery of technical products to ASP. Milestone completion constitutes the delivery of technical products from the API to the PI or PD.

2.3.1 NextGen-SAIE Project Milestone Change

The process for documenting concurrence and approval of milestone changes is as follows:

1. The Milestone Change Form will document the API's request to the PI for approval to change any one or more of the following elements of a milestone:
 - Title or description
 - Start or end date
 - Slip of more than one quarter within the fiscal year or any slip from one fiscal year to the next.
 - Dependencies
 - Deliverables
 - Metric
 - Exit Criteria

- Other [as determined by the API/APM]
- 2. Reason for change
- 3. Description of change
- 4. Impact of change

The API and the APM will develop the form jointly. It will be coordinated with the PS, and submitted to the PI for approval. If the milestone is a Key Milestone, Integrated Budget and Performance Document (IBPD) Milestone, supports an Agency Performance Goal (APG), supports a High Performance Project Goal (HPPG), or is in the Program Assessment and Rating Tool (PART), the PI will obtain the Program Director's approval for the Change. Once the form is signed off, it will go to the Project Manager, who will assign a Milestone Change Control Number. A copy of the form will then be provided to the Scheduler for any adjustment to the schedule.

2.3.2 NextGen-SAIE Project Milestone Completion

The process for documenting concurrence and approval of milestone completion is:

1. The Milestone Completion Memo will document the completion of any milestone. It will be submitted by the API to the PI and will state briefly how the following was accomplished:
 - Exit Criteria
 - Metric met. If not fully met, what part of the metric was met and what is the anticipated impact of not fully meeting?
2. Applicable reports or supporting documentation will be attached to the memo. (e.g., Technical report, simulation report, briefing charts)
3. Any additional information the API might want to provide as FYI to the PI should be attached to the memo.

The API and the APM will develop the memo jointly. It will be coordinated with the PS, and submitted to the PI for approval. If the milestone is a Key Milestone, IBPD Milestone, supports an APG or HPPG, or is in the PART, the PI will obtain the Program Director's concurrence in the acceptance of the completion of the milestone. Also, if the completed milestone is a Key Milestone, IBPD Milestone, supports an APG or HPPG, or is in the PART, a two page PowerPoint explanation of the results will also be required. Once the memo is signed off, it will go to the Project Manager for archive. A copy of the memo will then be provided to the Scheduler for any adjustment to the schedule.

2.4 Work Breakdown Structure

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Table 6. Work Breakdown Structure

Table removed from External Release version of Project Plan

2.5 Risk Management

SAIE will utilize the NASA Continuous Risk Management process as its approach to risk management. As part of the Project's approach to managing risk, the Project has developed a Continuous Risk Management Plan, Version 1.1, dated November 2008. Although created as an Airportal document, the same approach will continue to be utilized for the SAIE. The Project will consider its approach to managing risk to be successful if APIs and RMs accomplish the identification and resolution of risk issues prior to impact on research tasks or Project outcomes. As an enhancement to this process, the project also tracks technical risk by milestone. Research findings sometimes indicate original milestone schedules or deliverables are inconsistent with desired outcomes. Milestones at risk of delay, or not delivering on original metrics are tracked in a similar manner as the project or program management risks. While tracking technical risks, the risk manager will conduct monthly risk meetings to track progress and provide assistance with mitigation of the risks to enhance likelihood of outcome success.

2.6 Acquisition Strategy

The Project's acquisition strategy for addressing the air traffic management R&D needs of the NextGen as defined by the JPDO is compliant with ARMD policy and includes:

- Maintaining NASA's core capabilities in ATM research to the extent practical within resource guidelines
- Conducting full and open NASA Research Announcement (NRA) solicitations as the means to solicit innovative proposals in key research areas that complement NASA expertise. One of the main objectives of the NRA investment is to stimulate close collaboration among NASA researchers and NRA award recipients to ensure effective knowledge transfer. Each year the SAIE Project has a minimum required NRA funding level. NRAs will be used to perform research activities for which in-house expertise may not be available. These awards will also help strengthen the research capabilities that are of interest to NASA within the recipient organizations and institutions.
- Use of NRAs. Table 7 identifies the NRA subtopics that have been awarded to date, and new subtopics currently being prepared. Project support such as technical writing for operational concepts, code development, and use of non-NASA facilities will be exempt from the NRA requirement.
- Use of Space Act Agreements (SAA) to collaborate with industry, and to establish partnerships with other government agencies (FAA, DoD, DoT, etc.)
- Use of existing performance-based in-house contracts to support research activities at Ames and Langley is expected throughout the life of the Project. New requirements, or unforeseen events and circumstances will require Project

adjustments that may involve acquisitions not planned at this point. In all cases, full and open competition will be observed.

- Utilization of the Small Business Innovative Research (SBIR) Program. The SBIR program solicitation is created by Project leadership and focuses on higher risk, innovative ideas to fund typically low TRL research that is aligned with the Project but is not on the critical path. Funding is provided by the SBIR office.

Table 7. Current NRA Subtopics

Title Of Proposal [Organization]	RFA	Award Date	Period Of Performance
Airportal Functional Allocation Reasoning (AFAR) [Aptima Inc.]	ATIM	09/30/08	1 Yr Base, w/ 2nd And 3rd Yr Options
A Predictive Tool For Proactive Airportal Operations [S A Technologies, Inc.]	ATIM	09/30/08	1 Yr Base, w/ 2nd And 3rd Yr Options
Development Of Algorithms And Techniques For Trajectory Prediction Accuracy And Uncertainty Estimation [L-3 Services, Inc.]	IR	11/27/06	11/27/06-1/29/10 (No Cost Extension from 11/27/09)
Trajectory Flexibility Preservation And Constraint Minimization For Distributed ATM With Self- Limiting Traffic Complexity [L-3 Services, Inc.]	IR	11/29/06	11/29/06-3/31/10 (No Cost Extensions from 11/29/09)
Identification, Characterization, And Prioritization Of Human Performance Issues And Research In The Transition To Next Generation Air Transportation System (NextGen) [San Jose State U. Foundation]	SPA	1/15/08	1/21/08-12/31/09 (No Cost Extension from 6/30/09)
Characterization Of And Concept For Metroplex Operations (Joint With NextGen-Airportal And - Airspace Projects) [Georgia Tech Res. Corp.]	SPA	08/08/07	7/11/07-7/10/10
Investigating The Nature Of And Methods For Managing Metroplex Operations [Mosaic ATM, Inc.]	SPA	8/14/07	8/14/07-12/31/09 (No Cost Extension from 9/30/09)
3X-Transparent Research Environment For Aviation Modeling (3X-TREAM) [Aptima Inc.]	SPA	5/20/09	5/09-5/19/10 (1yr Base w/ 2 Yr Options)
Computational Models Of Human Workload: Definition, Refinement, Integration, And Validation In Fast Time National Airspace Simulations [San Jose State U. Foundation]	SPA	9/28/06	10/1/06-9/30/10
Metroplex Operations (Joint With NextGen Airportal And -Airspace Projects) [George Mason University]	SPA	08/24/07	8/24/07-7/31/10 (No Cost Extension from 9/30/09)
Integrated Analysis Of Airportal Capacity And Environmental Constraints [Logistics Management Institute]	SPA	12/14/07	01/07/08-01/08/10
Multi-Scale Tools For Airspace Modeling And Design [University Of Virginia]	SPA	2/11/08	03/01/08-05/31/10 (No Cost Ext. from 8/31/09)
Analysis Of NGATS Sensitivity To Gaming [George Mason University]	SPA	11/1/06	10/1/06-9/30/10

2.7 Partnerships and Agreements

2.7.1 NextGen CTD—SAIE Project Interface

The successful transition of concepts and technologies to stakeholders depends on SAIE and CTD projects working in a coordinated manner. To facilitate this transition, the two projects have identified roles based on Technology Readiness Levels (TRL), likely transition paths that concepts or technologies may find themselves on, Research Transition Teams to conduct transition activities, the actual coordination strategy that CTD and SAIE projects utilize, and a plan to evaluate pop up ideas or unexpected research opportunities.

TRL responsibilities between projects follow closely with the projects primary roles see table 8. At the lower TRLs (TRL 1-3), the CTD project is the lead project for these roles. At TRL 4, the opportunity and need for the projects to work together as co-leads are common. SAIE leads activities at TRL 5-6. TRL 5-6 concepts and technologies that have work tasks at the TRL 1-3 level will have these tasks handled by CTD and TRL 4 work will be handled by the appropriate project based on the work documented in the milestone and milestone records.

Table 8. TRL Responsibilities between Projects

TRL (NASA SE Manual)	Activity	Lead Project
1. Basic principles observed and reported	Bottoms-up, inductive logic, researcher generating an idea -Top-down domain studies to generate better understanding of domain characteristics and constraints; identify potential solution path	CTD
2. Technology concept and/or application formulated	Formulate individual concepts/ideas; algorithms formulated to address a specific operational need Potential solution paths further analyzed; benefit assessments to identify possible impacts and to identify technological challenges (R&D needs)	CTD
3. Analytical and experimental critical function and/or characteristic proof of concept	Conduct initial analysis to show the merits of the concept/ideas/algorithms Conduct thorough benefit assessments; evaluate potential benefits of combined concepts	CTD
4. Component and/or integrated components validation in laboratory environment	Conduct validation of initial integrated (as needed) concept prototype in a laboratory environment Develop initial technology prototype; validation in laboratory environment.	CTD and SAIE
5. Component and/or integrated components validation in relevant environment	Develop relevant environment, scenarios, and integrate multiple components Continue to mature a concept and technology based on simulation results	SAIE
6. System/subsystem model or prototype demonstration in a relevant environment	Integrate technology prototype in high-fidelity relevant environment; conduct testing and evaluation; update benefit, safety, and human factors assessments. Provide the concept/ technology prototype, description and algorithms for necessary demonstration	SAIE

TRL (NASA SE Manual)	Activity	Lead Project
7. System prototype demonstration in an operational environment	Support transition of technology to FAA; prototype modification to address site-specific operations; integration with other facility tools that operate in same environment Provide concept/algorithm modifications and descriptions as necessary to support technology transition	SAIE and CTD
8. Actual system completed and demonstrated in operational environment	No Project responsibility	No Project responsibility
9. Actual system operationally proven through use in operational environment	No Project responsibility	No Project responsibility

Research transition paths to stakeholders vary depending on the type of product and/or interest of the stakeholder. Activities include integrated concepts/technologies that require complex, high fidelity simulations, interoperability/interactions considerations, and involvement of multiple RFA items/concepts/technologies. Another work area needing both projects is the conducting of testbed demos or field tests at appropriate sites. Demos in testbeds have been discussed with the FAA as a stakeholder and the NASA NTX testbed will facilitate appropriate demos either independently or in the future in conjunction with the FAA testbed under development. Field tests will identify appropriate environments to use and may include FAA field sites such as Air Route Traffic Control Centers or “Centers”, Terminal Radar Approach Control facilities or TRACONS, and Airport Towers.

In the second transition path, SAIE transitions a product to external stakeholder directly. Tools or technologies being developed by SAIE and made available to stakeholders transition directly to the stakeholder. Analysis being conducted may also be conducted with or leveraged directly by stakeholders based on coordination or agreement. A key stakeholder for these types of products is the JPDO’s IPSA division.

In the third transition path, CTD transitions a product to external stakeholder directly. This is usually a low TRL product that may have been defined by; a stakeholder’s eagerness to transition at an early TRL, a stakeholder’s need for early decision making, or a stand-alone item.

The various transition modes available demand that CTD-SAIE have a coordination strategy to keep foundation research unencumbered and still ensure that the research has a maturation and transition path to stakeholders. In order to accomplish this, CTD and SAIE will work together to accelerate high impact products based on stakeholder interests. Products include technologies, concepts, algorithms, prototypes, or knowledge such as functional allocation. CTD is focused on individual concept and technology development with a deeper focus. SAIE is focused on system-level, integration, and technology transition considerations with a broader focus. In each case, specific understanding between CTD and SAIE needs to be developed. Each technology or concept is likely to have differing needs and different involvements. Activities requiring joint efforts are defined jointly by both projects PI/PM/PS. During the

course of normal project development CTD and SAIE will negotiate on how the collaboration will be handled year to year based on the unique requirements of the current concepts and technologies development phase they are in. This collaboration will be documented in the milestones and the associated milestone records for the upcoming year.

Research Transition Teams (RTTs), jointly established with the FAA, have been implemented to help identify research and development needed for NextGen implementation and to ensure that the research is conducted and effectively transitioned to the implementing agency. RTTs the projects are supporting jointly with FAA in all cases:

- Efficient Flow into Congested Airspace (EFICA) is the responsibility of the SAIE project and focuses on a few key technologies in the dense arrival/departure area such as merging and spacing including work with FAA's ATO-P and SBS office, Efficient Descent Advisor, including field test at FAA's Denver Center.
- Flow-based Trajectory Management (Multi-sector Planner) is the responsibility of the SAIE project with focus on identifying the feasibility and benefits of the Multi-sector Planner. This is a concept study with human in the loop simulations for demonstration to FAA.
- Integrated Arrival/Departure Surface (IADS) is the responsibility of the SAIE project and includes research from the CTD project. It includes the Precision Departure Release Capability that will conduct testbed studies at NASA's NTX facility. Also, the airport surface optimization is scheduled to conduct similar studies at NTX in the near future.
- Dynamic Airspace Configuration (DAC) RTT remains the responsibility of the CTD being long-term focused research.

RTTs are supported by CTD and SAIE milestones, some of them jointly.

Occasionally, unplanned research opportunities present themselves to the projects and program. These "Pop-up" concept or technology ideas may come from internal project staff or external stakeholders. Managing a new Pop-up Idea uses the following process:

- CTD/SAIE PI/PS/PM and involved researcher(s) meet to discuss idea. The Project team prepares the proposal to the Program with three options; pursue, don't pursue, or more information/base work/analysis is needed before decision. "Seedling" and other possible sources of funding explored.
- Host center management and partner center POCs and/or designees will be involved throughout the process.
- Program will make the final decision based on committee/board input.

2.7.2 Partnerships

The SAIE Project will seek partnerships with industry, universities, JPDO, and other government agencies in research related to SAIE goals and objectives. Early

involvement of these entities, combined with frequent input, will be necessary throughout the development and validation of the NextGen concepts and research. The development of system-level capabilities and integrated systems is a high TRL effort that is appropriate for collaboration with industry partners and other government agencies. SAIE will consider the following when assessing potential collaborations:

- Collaborations are established only when there is significant benefit to NASA and its constituencies (aerospace community, aerospace industry, academia, and ultimately the U.S. tax-payer).
- Once the collaboration is established, the results can be appropriately disseminated and validated through a peer-review process.

Additional guidelines to be considered:

- Is the collaboration suitable for NASA to pursue?
- Does the collaboration help advance and disseminate knowledge and technology?
- Have we ensured that restrictions for data distribution do not prevent the advancement of knowledge in the specific discipline?

2.8 RTTs

Research Transition Teams (RTTs), jointly established with the FAA, have been implemented to help identify research and development needed for NextGen implementation and to ensure that the research is conducted and effectively transitioned to the implementing agency. RTTs that the SAIE Project is supporting are (jointly with FAA in all three cases):

- Integrated Arrival/Departure/Surface (near- and mid-term) RTT
- Efficient Flow into Congested Airspace (near- and mid-term) RTT
- Flow Based Traffic Management (mid-term) RTT

RTTs are supported by CTD and SAIE milestones, some of them jointly. For more details refer back to section 1.2.3 on project interface with CTD.

2.9 Foreign Collaboration

The Airspace Systems Program and its legacy projects actively established participation with foreign organizations to conduct joint ATM research. The NextGen SAIE Project is committed to maintaining these efforts, where appropriate, and to identifying new areas of opportunity for foreign collaboration. Existing and new foreign collaborations will be aligned with the six Project RFAs.

To facilitate foreign research collaboration, the NextGen SAIE Project will follow guidelines for capturing and documenting foreign collaborative research efforts established by the NextGen-Airportal Project. The guidance is in full compliance with the U.S. Department of State's International Traffic in Arms Regulations (ITAR) policy and amendments related to project research (e.g., trajectory prediction, algorithms). Titled, "NextGen-Airportal Project Guidance on Foreign Collaboration", the guidance document is tailored to NextGen ATM research and will serve as a template for current

and future collaborative research. Rather than inhibit or discourage foreign research collaboration, the guidance is intended to facilitate and encourage collaboration where it can be demonstrated that the collaboration will add value to Project, Program, and ARMD mission, goals, and/or objectives.

The API in the respective RFA is empowered with, and responsible for, identifying new opportunities for foreign collaboration and for managing existing and new foreign research collaboration, and will coordinate with both Project and Line management. A formal review and approval process has been developed for use in evaluating foreign collaboration proposals for consistency with Project, Program, and ARMD mission, goals, and/or objectives. Questions that must be adequately addressed by the API include, but are not limited to, the following:

- Is there a formal charter for the proposed research that delineates tasks, responsibilities, and time period?
- What vehicle will be utilized for the formal agreement (e.g., Action Plan, Letter of Authorization, Memorandum of Authorization)?
- What are the respective responsibilities between NASA and the relevant foreign organization(s)?
- Which organization(s) are responsible for assigning and managing research tasks?
- What amount of effort is required to fulfill the duties (e.g., preparation, travel, meetings)?
- Will the conduct of the foreign research impact the completion of any NextGen CTD Project milestones?
- Is the research directly related to any Project milestones? If so, which milestone(s) are related?
- Does the research provide an advantage to foreign companies at the expense of the U.S. taxpayers? If the answer is no, why not?
- How will the performing organization(s) accommodate new requests for additional or follow-up research?
- Who will approve additional or follow-up research?

The API shall address these questions in a letter of interest and submit it to the PI for formal approval of the proposed foreign collaboration. The API should allow 30 days for Project Office and Program review and approval or rejection. Once an agreement is in place, the API will be responsible for managing foreign collaboration research.

2.10 Knowledge Dissemination

The SAIE Project will disseminate research results to the greatest extent practicable in as timely a manner as possible. The quality of the technical work performed in the Project will be assessed against milestone metrics through informal and formal SAIE management reviews, and peer internal and external reviews. Technical publications, peer-reviewed journal articles, and invited papers and presentations will quantify the level of technical dissemination of SAIE research. This strategy aligns with the ARMD

objective of advancing knowledge in the fundamental disciplines of aeronautics, and is in keeping with the Space Act of 1958 that requires NASA to “provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.”

Future programs and projects benefit from the knowledge and understanding gained during the formulation, implementation, and execution of past and current programs and projects. Lessons learned will be documented and shared with other ARMD projects. Documented lessons learned, when appropriate, will be shared with Center and Headquarters’ Systems Management Office or Chief Engineer’s Office.

3 TASK PLANNING (MILESTONE RECORDS)

Current task planning and the preparation of Milestone Records for the SAIE project are primarily focused on FY10 research. The objective of developing the Milestone Records is to define the detailed requirements, work, resources, labs, major facilities, and task deliverables, to conduct SAIE research in FY10. The APIs and APMs, working with Research Managers (RM) and facility managers, developed task plans for their respective RFAs. The Milestone Records document the research to be conducted and the resources estimated to accomplish the work. As such, they will be the contract between the APIs, RMs, and the PI. Updated task planning for FY11 will take place during the 4th quarter of FY10. Coordination between the SAIE and CTD Projects is critical to their success and forms a cornerstone of their planning and research efforts.

Appendix A. SAIE Project Roles and Responsibilities

Principal Investigator (PI) working with Associate Principal Investigators (API):

- Responsible and accountable to the Airspace Systems Program (ASP) Director (PD) for the planning (technical and resource) and execution of the Project – signs Project Plan contract with Project Manager (PM) and Center POC
- Works with the PM to plan and execute the Project Plan
- Works with a Project Scientist (PS) to ensure integrity and soundness of the technical plans
- Provides guidance to the Associate Principal Investigators (API) for the development of the technical plans
- Reviews Project performance
- Works with the PM to ensure budget and schedule support research requirements
- Works with the PS to ensure technical plans align with technical priorities
- Works with PS, and APIs to ensure appropriate technical progress toward Project goals
- Facilitates partnership opportunities (e.g., NRA, RFI, SAA)
- Interfaces with all ASP Projects to integrate research requirements as appropriate
- Insures technical excellence within the Project
- Ensures high quality technical papers and presentation
- Ensures multiple viewpoints are considered in recommending technical direction
- Represents the Project externally
- Seeks collaboration opportunities with industry and academia
- Identifies opportunities to transfer Project technologies and solutions
- In consultation with the PD, recommends international collaborations
- Insures the Project is aligned with JPDO NextGen requirements

Project Manager (PM) working with Associate Project Managers (APM):

- Responsible and accountable to the PI for the planning and execution of the Project – signs Project Plan contract with PI and Center POC
- Reviews Project fiscal performance
- Facilitates partnership opportunities (e.g., NRA, RFI, SAA)
- Works with the APMs to monitor Project Plan cost and schedule
- Interacts with AS program office to ensure soundness of Project budget and schedule
- Provides resource and schedule risk mitigation recommendations to the PI to enable research success
- Establishes business practices to be followed by the Project team
- Leads configuration control process of Project documentation
- Advises the PI in areas of his/her technical expertise

Project Scientist (PS) working with Principal Investigator (PI):

- Serves as the technical authority and is responsible and accountable to the PI for the technical integrity of the technical plans
- Ensures technical excellence across the breadth of the Project
- Provides technical input to facilitates partnership opportunities (e.g., NRA, RFI, SAA)
- Supports the cross-Project integration to leverage synergistic and complimentary research within the Program
- Leads the NASA Research Announcement (NRA) and Small Business Innovation Research (SBIR) Processes to integrate innovative, high-risk ideas from academia and industry. At the direction of the PI, the PS may delegate to the APIs the responsibility to lead these processes in their research areas.

Associate Principal Investigator (API) working with their Research-matrixed team (to include the Research Manager):

- Is responsible and accountable to the PI for supporting the technical content and the task plan contract execution of the topic area – signs task plan contracts with APM and Research Manager/Facility Manager, concurrence with PI
- Delegates task plan execution of the topic area to the APM
- Leads the development of the technical plan
- Manages the technical progress; report status to PI and PS
- Evaluates the results of the technical plan
- Resolves technical issues within the technical plan and provide recommendations to the PI and PS for redirection based upon lessons learned
- Provides modifications to the technical requirements of current task plan as required or agree on alternate resolution, working with the Research Manager and APM
- Serves as subject matter expert giving technical advice to PI, PS, and PM as required
- Leads formulation and selection of NRA topics for his/her research area when delegated by the PS

Associate Project Manager (APM) working with the PM and across Centers with business teams:

- Is responsible and accountable to the API for supporting the task plan contract execution across Centers—signs task plan contracts with API and Research Manager, in concurrence with PI
- Manages implementation task plan cost and schedule, and workforce allocations
- Resolves resource barriers (e.g., procurement acquisitions, funding flow)
- Resolves schedule burdens (e.g., facility access)
- Provides recommendations for efficient and effective task execution based upon constraints; work with PM, PI, PS, and API to modify implementation requirements to address progress impediments of a technical nature; work with PM and PI to modify implementation requirements to address progress impediments of a resource (i.e., dollars, personnel, facility) nature

Research Manager:

- Is accountable to the API to support the task plan contract implementation at their Center—signs the task plan contracts with the API and APM, in concurrence with PI
- Creates an environment to encourage technical excellence
- Develops skills and capabilities in their personnel to support ARMD programs
- Provides workforce and facilities to implement the task plan contract
- Monitors task implementation to achieve a level of awareness of subordinates work and technical objectives of the specific task plan
- Monitoring should provide insight to success and impediments of progress requiring Program and Center coordination
- Monitoring should enable insight to technical questions that may result in a Center ITA process
- Monitoring functions will include approval of purchase requests, travel orders, WebTADS, and award of contracts/tasks (e.g., PBC) as defined within the task plan contract
- Resolves issues of an internal nature (i.e., facility use conflicts, workforce challenges) with the Center POC and notifies APM
- Modifies technical implementation as a result of API decision; works with API and APM to modify task plan contract if appropriate
- Resolves implementation impediments with the APM; works with API and APM to modify task plan contract if appropriate

Researchers, technicians, scientists, and support personnel day-to-day responsibilities:

- Is accountable to the API/APM for execution of the research in support of the task plan contract
- Highlights any imposed execution impediments to the Research Manager and API for resolution
- Resolves technical impediments with the API and Research Manager
- Resolves implementation impediments with the APM and Research Manager
- Participates in technical forums and conferences to share knowledge gained within execution of the Project
- Publishes technical peer reviewed papers
- Understands overall task plan motivation and propose ideas/alternatives to improve task and Project quality and impact
- Enables, through communication, the Research Manager to maintain a level of awareness of research activities

Business Team:

Business Team personnel work with the PM to provide Project reporting and analysis of resources (i.e. workforce and dollars) and schedule. All of the Business Team members are assigned directly to the Projects. The roles below describe functions important to Project operations. Within a given Project, several of these roles may be filled by a single individual. Full discretion is vested in the PM to determine how

this will be done in the best interest of the Project. Team consists of the following (only the Resource Analyst is a full FTE per Project):

- **Resource Analyst:** Assists in budget development, service pool, and workforce planning across all Centers. Tracks Project(s) budget. Provides timely budget & workforce analysis detail as requested by the PM/APM. Assists PM/APM in identifying budget and workforce issues and timely issue resolution. Assists in the development of POP/phasing plans and is involved in all phases of budget cycle. Works closely with Center Chief Financial Officer (CFO) office.
- **Scheduler:** Provides Project schedule as requested by the PM/PI. Implements schedule changes. Provides advice on schedule improvements. Solicits necessary data from Project personnel for schedule development and updates. Maintains up-to-date schedule.
- **Risk Manager:** Develops resource and schedule risk management strategies and makes recommendations to the PM to enable research success.
- **External Agreements and Intellectual Property Manager:** Oversees NRA process including recruitment of reviewers, assignment of reviewers to proposals, proposal evaluations (individual and consensus), final recommendation to PI, coordination with HQ for re-guideline of NRA funds according to location of Technical Monitors, tracking award commitments/obligations/accruals. Works with Technical Monitors to gather status information. Also, tracks existing SAAs and facilitates initiation of new SAAs and works to ensure agreements adhere to NASA IP guidelines. Provides support to all ASP Projects regarding Intellectual Property (IP) issues. Provides IP guidelines and recommendations for external agreements. Ensures publication rights for NASA.
- **Project Operations:** Provides support to the Project Leadership team including maintaining and archiving Project documentation. Provides configuration control of critical Project documentation. Provides and/or coordinates support for responding to ARMD actions to Projects. Serves as primary assistant to PM.

Assumptions:

- API and PS report to the PI; API may support more than one Project and may or may not be full-time on ARMD Projects. API and PS must be committed at least half time to the Project.
- PM and PS report to the PI
- APM reports to the PM and supports one or more APIs
- Researcher works with the APM to report progress to API, PI, PS, and PM
- Research Manager (i.e., Branch Chief, Division Chief) supervises the Researcher
- Center POC office may supervise the Research Manager
- API and APM may be supervised by the Research Manager but are not directly supervised by the Center POC
- API and APM cannot hold a supervisory position

- PI, PM, PS are not supervised by the Research Manager or the Center POC
- PI, PM, PS cannot hold a supervisory position
- Business Team members are not directly supervised by the Center POC
- Performance reviews for PI, PM and PS are handled at the Centers with input from the PD

Appendix B. Acronyms and Abbreviations

4D	Four Dimensional	NTX	North Texas Facility
AA	Associate Administrator	OI	Operational Improvement
ACES	Airspace Concept Evaluation Tool	PAM	Path Arrival Management
AOL	Airspace Operations Laboratory	PART	Program Assessment and Rating Tool
APG	Agency Performance Goal		Precision Departure Release
API	Associate Principal Investigator	PDRC	Capability
APM	Associate Project Manager	PI	Principal Investigator
	Aeronautics Research Mission	PM	Project Manager
ARMD	Directorate	POC	Point of Contact
ASP	Airspace Systems Program	PS	Project Scientist
ATC	Air Traffic Control	R&D	Research and Development
	Airportal Transition and Integration	RFA	Research Focus Area
ATIM	Management	RTP	Research Transition Product
ATM	Air Traffic Management	RTT	Research Transition Team
CAP	Collaborative Arrival Planning	SA	Separation Assurance
CONOPS	Concept of Operations	SAA	Space Act Agreement
CPTP	Conflict Prediction and Trial Planning		Systems Analysis, Integration and
	Concepts and Technology	SAIE	Evaluation
CTD	Development	SDO	Super-Density Operations
DAC	Dynamic Airspace Configuration	SESO	Safe and Efficient Surface Operations
DoD	Department of Defense	SPA	System and Portfolio Analysis
DoT	Department of Transportation	TBO	Trajectory-Based Operations
DST	Decision Support Tools	TE	Test Engineer
EDA	En Route Descent Advisor	TFM	Traffic Flow Management
EFICA	Efficient Flow into Congested Airspace	TMA	Traffic Management Advisor
ERAM	En Route Automation Modernization	TMI	Traffic Management Initiation
FAA	Federal Aviation Administration	TP	Trajectory Prediction
FAST	Final Approach Spacing Tool	TP/I	Trajectory Prediction/Interoperability
FMS	Flight Management System	TRACON	Terminal Radar Approach Control
FTE	Full Time Equivalent	TRL	Technology Readiness Level
FY	Fiscal Year	TRL	Technology Readiness Level
FYI	For Your Information	WBS	Work Breakdown Structure
HSI	Human Systems Integration	WYE	Work Year Equivalent
HPPG	High Performance Project Goal		
IADS	Integrated Arrival/Departure/Surface		
	Integrated Budget and Performance		
IBPD	Document		
IET	Integration, Evaluation and Transition		
	Interagency Portfolio and System		
IPSA	Analysis		
IR	Interoperability Research		
IWP	Integrated Work Plan		
JPDO	Joint Planning and Development Office		
MSP	Multi-Sector Planner		
NAS	National Airspace System		
	Next Generation (Air Transport		
NextGen	System)		
NRA	NASA Research Announcement		

Appendix C. Milestone Change Tables

REVISION	DESCRIPTION OF CHANGE	RESPONSIBLE AUTHOR	EFFECTIVE DATE

Appendix D. Change Log

REVISION	DESCRIPTION OF CHANGE	RESPONSIBLE AUTHOR	EFFECTIVE DATE
1.0	Baseline Document	N. O'Connor	May, 2010

Appendix E. Milestone Records

(Separate Document – Enclosed)

Appendix F. Review Comments and Discussion

Text removed from External Release version of Project Plan

Appendix G. NASA Priority Performance Goal in Aeronautics Research

Increase efficiency and throughput of aircraft operations during arrival phase of flight.

1. Problem being addressed

Current air traffic control operations require an air traffic controller to manually generate and provide clearances (that include path and speeds) to aircraft to arrive at a “meter fix” at a scheduled time during the arrival phase of flight. A meter fix is an established point on a route used to time-regulate traffic entry into an airport’s terminal area. This manual process often results in inefficient trajectories and descent profiles for aircraft, particularly during higher traffic density operations, restricting the throughput, or number of aircraft that can be processed for arrival operations, and increasing negative environmental impacts from the inefficient trajectories, including “stair step” approaches (level off, descend, level off, descend, etc.) or holding.

The En Route Descent Advisor (EDA) is a tool that proposes to the air traffic controller the speed and path changes which will allow an efficient arrival profile. EDA monitors many aircraft simultaneously, maximizing throughput by ensuring that each aircraft meets its scheduled time at the meter fix while avoiding flight path conflicts. The EDA’s innovation is its transformation of operations from existing procedures to ones that reduce flight time, fuel consumption, noise and emissions, thus resulting in more environmentally friendly enroute and terminal operations. Benefits from the use of off-line EDA-developed trajectories, tested in 2007 at San Francisco with a procedure called Tailored Arrivals in an oceanic environment, are already being realized by our international and domestic airline partners (Qantas, JAL, United, New Zealand Airlines) at San Francisco and Los Angeles airports. The San Francisco Trials indicated efficient trajectories could reduce fuel consumption by as much as 3,000 pounds for large aircraft, with a corresponding reduction of carbon dioxide of up to 10,000 pounds per flight.

Initial procedures and EDA capabilities for domestic operations will be different than the oceanic operations due to differences in flight instrumentation, traffic densities, and procedures. Field testing and subsequent deployment of EDA for en route domestic airspace will allow efficient operations, particularly during heavy traffic periods, and the economic and environmental benefits described above.

2. Relationship to broader agency objectives

The EDA technology supports environmentally responsible operations by creating efficient trajectories while maintaining higher throughput during the arrival phase of flight. It saves fuel and thereby reduces emissions.

NASA’s Aeronautics Research Mission Directorate conducts and supports research that enables revolutionary advances in civilian and military aeronautical systems, for both aircraft and the airspace in which they fly. As such, it addresses the Agency sub-goal

3.E: Advance knowledge in the fundamental disciplines of aeronautics, and develop technologies for safer aircraft and higher capacity airspace systems; and Outcome 3.E.2: By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility, and efficiency, while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System (NextGen).

3. *Contributing programs within the agency*

The Aeronautics Research Mission Directorate's Airspace System Program is the sole NASA sponsor of this technology.

4. *Contributing programs outside the agency*

EDA has been transitioned to the Federal Aviation Administration's 3D Path and Arrival Management project and forms the core technology for the project. It also supports the Joint Planning and Development Office's (JPDO) Next Generation Air Transportation System vision for increasing throughput of the National Airspace System and reducing environmental impact. The JPDO is a federal planning office designed to create and carry out an integrated plan for NextGen, spearhead planning, and coordinate research, demonstrations and development in conjunction with relevant programs of partner departments and agencies, and with the private sector. The JPDO is comprised of representatives from DOT, DOD, FAA, DHS, DOC, NASA, and OSTP. U.S. industry is engaged in JPDO activities through its involvement in the NextGen Institute.

5. *Key barriers and challenges*

The main technical challenge is the development of conflict free trajectory-based solutions that will meet the aircraft arrival scheduled time as well as maintain high throughput. This challenge requires the computation of accurate trajectory predictions under real-world conditions, and effective and robust decision-making algorithms. The other barrier is acceptance of this technology by users. In order to ensure that the technology is acceptable and beneficial to the users, a number of human-in-the-loop simulations and two field tests are planned.

6. *Implementation strategy overview*

In September 2009, NASA will work with FAA, United Airlines, and Continental Airlines to begin the first field test of the En Route Descent Advisor capability. During this first field test, United, Continental, and FAA Tech-Center aircraft will receive pre-scripted speed and path clearances representative of those computed by EDA. The goal of this first field test is to collect data for post-flight evaluation of EDA trajectory-prediction errors. Based on these data, models will be developed to better represent expected EDA trajectory errors in human-in-the-loop simulations, thereby providing a better representation of real-world performance.

The second field test is planned in March 2011. In this field test an EDA prototype will be deployed for real-time decision-making. The speed and path adjustment advisories will be presented on air traffic controllers' displays.

The primary mechanism for deployment is the NASA-FAA Research Transition Team (RTT). The RTT members develop the concept, operational procedures, and scenarios, and assess technology readiness. The FAA and NASA jointly identified EDA as one of the main technologies for potential deployment.

7. Quarterly measures and milestones

FY09

1. Denver Field Trial (first): Validation of EDA trajectory predictions and 3D Path and Arrival Management (4Q FY09)

FY10

1. Denver field trial lessons learned documented and used as input into experiment plan and model development (1QFY10)
2. Experiment plan and model development for human-in-the-loop simulation (1QFY10)
3. Human-in-loop simulation to evaluate EDA's core algorithmic performance (2QFY10)
4. Report on human-in-the-loop simulation and model results (4Q FY10)

FY11

1. Experiment plan development for field test (2QFY11)
2. Denver field test (second): EDA evaluation by actual controllers (4QFY11)

FY12

1. NASA delivery of EDA Technology Transition Documentation to the FAA, September 2012

The ultimate achievement of any NASA air traffic management concept or technology is its use by the FAA in implementing operational improvements in the National Airspace System (NAS). Since NASA has no operational responsibility for the NAS, NASA's role and value is in providing information and capability to the FAA for informing critical decision-making as they plan investments. For NASA research deliverables, the ultimate achievement is to be captured in FAA implementation roadmaps enabling key deployment decisions, whether the deliverables are data, analysis, algorithms, or decision support tools for use by pilots or controllers. These deliverables are accompanied by a technology transition document, which identifies the maturity of the technology product and delivery requirements as defined jointly by NASA researchers and FAA operational personnel. The transition documents often involve careful analysis and negotiation to ensure maximum value and benefit is transitioned.